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Effectiveness of Artificial Bark Flaps in Mediating Migration of Late-Instar Gypsy Moth Larvae

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Abstract

Field studies demonstrated that migrating larval instars of the gypsy moth, *Lymantria dispar* (L.), preferred resting locations placed on tree boles at 4.6 m over those placed at 1.5 and 3 m. More larvae were found beneath bark flaps than beneath flaps of hard black plastic.

ODC 145.7 x 151.2

During the 4th instar, gypsy moth, *Lymantria dispar* (L.), larvae in sparse populations feed during the night and rest during the day in protected locations that are often far removed from the foliage, either on the tree trunk or at or near the base of trees. These locations include holes or wounds, deep bark fissures, dead stumps or snags, and bark flaps. Bark flaps are similar to the loose plates of bark found on shagbark hickory, *Carya ovata* (Mill.) K. Koch, and may be caused by lightning strikes or by the bark separating from the cambium on dead branches or stems.

The movement of larvae to the foliage at night and from the foliage in the early morning is very precise and apparently triggered by low intensities of light.¹ McManus and Smith (1972)

¹ McManus, M.L. and Neely, R. Gypsy moth larval migration as a function of light intensity. Unpublished report on file at the Northeastern Forest Experiment Station, Center for Biological Control of Northeastern Forest Insects and Diseases, Hamden, Connecticut.

found that many larvae use silk trails to return to the same resting sites on consecutive mornings. The importance of this diel behavior of instar IV-VI gypsy moth larvae to their survival has been well documented (Bess et al. 1947; Campbell et al. 1975, 1977).

With this knowledge of larval behavior, both researchers and regulatory personnel have used simulated bark flaps, consisting of burlap or heavy-gauge black plastic, to detect or monitor gypsy moth populations, especially in outlying infestations or where numbers are very low (less than 60 egg masses/ha). Homeowners also are being encouraged to use this practice as an early warning device to detect the presence of an infestation on their property before the population expands and causes noticeable defoliation (McManus et al. 1980).

Our objective was to quantify the selection by aggregating instar IV-VI larvae of vertically placed simulated bark flaps and to evaluate larval preference for bark or plastic flaps.

Materials and Methods

The study was conducted in August 1970, at the USDA Forest Service's Saltonstall field laboratory, located on New Haven Water Company property in Branford, Connecticut. Bark and plastic flaps were placed on 12 black oaks (*Quercus velutina* Lam.); the diameter at breast height (d.b.h.) ranged from 13 to 28 cm. Bark flaps consisted of 15.2- by 30.5-cm pieces of oak bark that were hinged at the top with canvas and stapled to the tree; plastic flaps were 15.2- by 15.2-cm pieces of stiff, heavy-gauge black plastic, folded in at the sides to form a canopy and then stapled at the top to the tree. On six trees—chosen at random—bark flaps were placed on the north and south sides of the bole at 1.5, 3.0, and 4.6 m; plastic flaps were placed on the east and west sides at each height. On the remaining six trees, the pattern of placement of the two materials was reversed.

Seventy lab-reared (ODell and Rollinson 1966), newly molted 4th instars were released at the base of each tree between August 1 and 13, when larvae from natural populations are not present. The numbers of larvae resting beneath the flaps were recorded daily for 2 to 3 weeks. Our prime interest was the propensity of larvae to select bark or plastic flaps at various heights, not the percentage of larvae established on individual trees. An analysis of variance for randomized blocks was used to test for differences among the number of larvae selecting bark or plastic flaps at the three vertical strata. Each tree was considered a block containing all treatments.

During an earlier study (July), we recorded the hourly temperature beneath bark and plastic flaps placed in both exposed (to solar radiation) and shaded locations on a large black oak with copper constantan thermocouples.

Results

The maximum number of larvae recovered on the trees was recorded within 4 days of their release and ranged from 10 to 53 ($\bar{X} = 21.6 \pm 11.7$). One tree was not included in the analysis because only a few larvae were recorded beneath flaps during a 2-week period.

Because preliminary analyses indicated no differences between aspect, the counts were combined (added) by direction, and the natural logs taken of "count + 1" to "normalize" the distribution. Both type of flap (bark or plastic) and vertical placement had a highly significant effect on \log_e average count/day of larvae (Table 1). There was no interaction between flap material and height. There were significant differences between trees and these differences were taken into account in the analysis.

Most larvae selected the bark flap (Fig. 1) over the plastic flap at all heights (Fig. 2). Three times as many larvae were found under bark than under plastic flaps. Twice as many larvae were found at 3 m than at 1.5 m; 8 times as many larvae were recorded at 4.6 m than at 1.5 m. Larvae never were observed resting in the litter near the base of trees during this experiment, indicating their preference for resting locations on the boles of trees.

Table 1.—Analysis of variance of the effect of flap height, flap material, and trees on the \log_e of average daily counts of late-instar gypsy moth larvae

Source	df	Sum squares	Mean squares	F
Height	2	58.18	29.09	31.64***
Material	1	32.39	32.39	35.23***
H x M	2	4.02	2.01	2.19 NS
Trees	10	18.84	1.88	2.05*
Error	50	45.97	0.92	—

*** $P < 0.001$.

* $P < 0.05$.



Figure 1.—Bark flap raised to show larvae resting beneath.

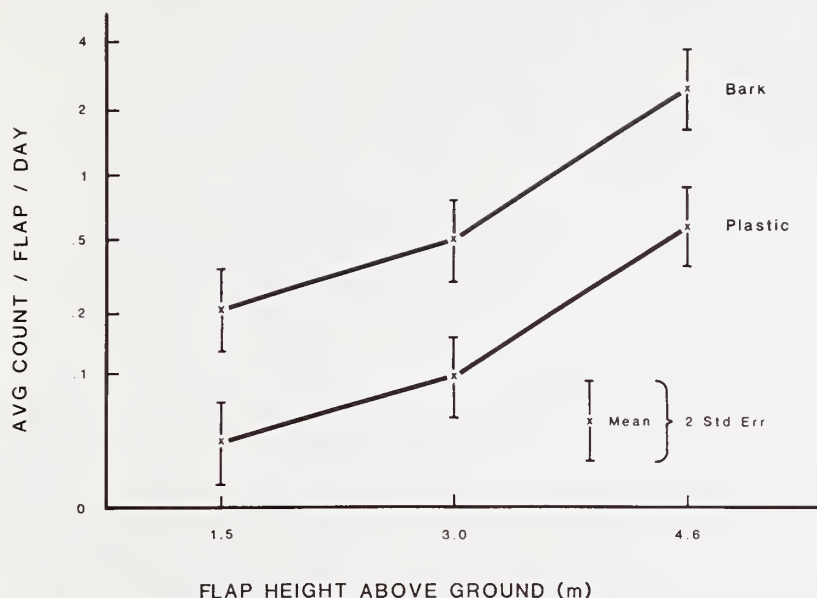


Figure 2.—Relationship between average larval count/flap/day and flap height and material.

Discussion

Campbell et al. (1975) reported on the patterns of occurrence of gypsy moth larvae in a sparse, stable population in northeastern Connecticut. Using only natural resting locations, they found that about 45 percent of instar IV-VI larvae were found more than 1.8 m above the forest floor; 45 percent were found within a vertical stratum between the litter and 1.8 m, and 10 percent were found in the litter. About 5 times as many larvae were found in 0.004-ha plots that contained more than three natural bark flaps than in plots that contained no bark flaps. Campbell et al. (1977) concluded that larvae that rested in bark flaps during the day were more likely to survive than those that rested in the forest litter, where they were vulnerable to predation by birds and small mammals.

Our data suggest that larvae usually seek bark flaps or other resting locations that are highest in the tree or first encountered in their downward diel movement. Although this study was

conducted after the normal seasonal period of larval development, we believe that the results are characteristic of observations made during related field studies.² Lab-reared larvae readily became established on the trees and apparently were not adversely affected by late-season foliage during the course of this experiment. McManus and Smith (1972) discussed the importance of silk trails in the selection of resting locations by late-instar larvae, and described how individually marked larvae returned repeatedly to the same bark flap. We observed the same pattern of behavior during this study. The number of larvae frequenting individual bark flaps on a tree varied during the first few days

² McManus, M.L.; Smith, H.R. The dispersal behavior of instar IV-VI gypsy moth larvae. Unpublished report on file at the Northeastern Forest Experiment Station, Center for Biological Control of Northeastern Forest Insects and Diseases, Hamden, Connecticut.

after their release but stabilized by the third or fourth day. There was no change in the pattern of counts thereafter.

A possible explanation for the apparent preference of larvae for bark over plastic flaps is that the thicker bark is a much better insulator and provides a more stable microenvironment for the resting larvae, while the black plastic absorbs radiation and is more subject to a wide range of temperatures (Fig. 3). At 10 a.m. on July 9, the temperature was 93°F (34°C) under the plastic flaps exposed to the sun; under the exposed bark flap the reading was 74°F (23°C). During the day, the mean temperature beneath both shaded and exposed plastic flaps was higher than beneath corresponding bark flaps. Rates of temperature increase and decline also were much greater beneath the exposed plastic flaps. On a warm, clear day, temperatures beneath the plastic flaps could rapidly become excessive, forcing larvae to relocate in more suitable sites on or off the tree. We observed late-instar larvae relocating in leaf litter at the base of trees when direct solar radiation caused litter temperatures to exceed 100°F (38°C).

Relative humidity or evaporation rate also could be an important factor in the selection of resting locations; however, we did not attempt to measure this variable. Bess et al. (1947) suggested that larvae migrated down into the litter and understory seeking cool, moist places in which to rest and pupate. Campbell et al. (1975) suggested that the larvae seek resting locations protected from moisture and light. However, Wallis (1959) was unable to demonstrate in the laboratory that gypsy moth larvae prefer a particular range of relative humidity in a gradient of moisture. Preferences of gypsy moth larval instars for temperature and moisture have not been determined experimentally.

Artificial bark flaps are sensitive devices for detecting and monitoring gypsy moth populations because they are used by late-instar larvae as resting locations, a behavior which increases their probability of survival. Larvae then pupate in these same locations, and

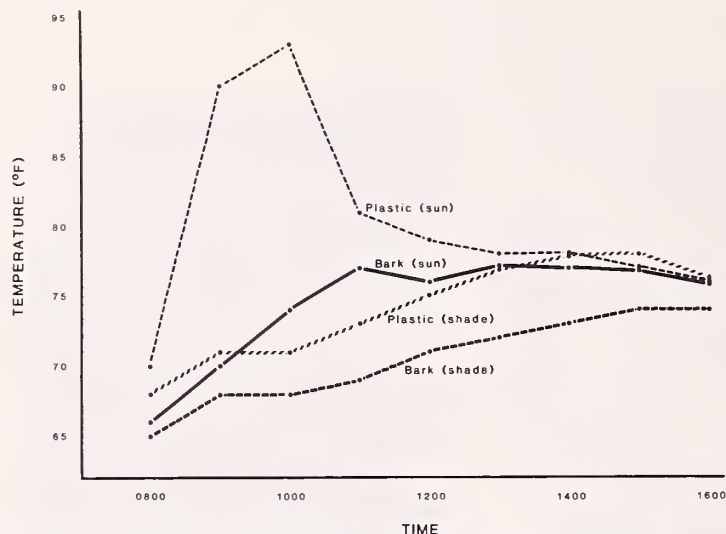


Figure 3.—Hourly recorded temperatures beneath bark and plastic flaps exposed to and shaded from direct sunlight.

emerging female moths usually mate and then deposit their eggs beneath the same bark flaps where they rested as larvae and pupae. Therefore, these life stages can be located beneath bark flaps long before they can be detected visually on or off trees in forested areas and woodlands.

In regulatory programs, artificial bark flaps can be used to confirm the presence of remote infestations after male moths have been detected with a systematic grid of pheromone traps. Within the generally infested area, artificial bark flaps should be incorporated into the surveillance component of a pest management program to assess the trend in gypsy moth populations in successive generations, thereby serving as an early warning system. Tactics designed to prevent or contain an outbreak can then be deployed more efficiently before populations reach defoliating levels over large areas.

A program of this kind has been initiated in a four-county area in Maryland that is on the southern fringe of the general infestation. A combination of pheromone traps and artificial bark flaps has been deployed on a 1-km grid to delineate and monitor gypsy moth populations, and will aid in decision-making about managing the insect in subsequent years as the infestation progresses.

Although natural bark flaps outperformed plastic flaps in this study,

we believe that the difference was caused by our using black plastic which, when exposed to sunlight, absorbed solar radiation and subjected larvae to extreme temperatures. Our current experience in Maryland suggests that a polyvinyl plastic flap, approximately 16 by 23 cm and reflective in color, is a good monitoring device for gypsy moth larvae. Two flaps stapled on opposite sides of preferred host trees (preferably oaks), 6 to 18 inches in d.b.h. at approximately 2 m above ground, will attract late instars that exhibit diurnal migratory behavior.

The efficiency of artificial bark flaps depends on the number and distribution of natural refugia on the tree proper. Bark flaps should not be placed on trees that contain obvious resting locations for larvae—such as large dead branches, or holes or wounds in the upper bole or crown—because larvae will use these sites and not descend to the lower bole.

As we accumulate data in consecutive years from bark flaps and male moth traps on sites containing a broad range of gypsy moth densities, we hope to develop a quantitative relationship between male moth capture and the relative density of populations when they are sparse and difficult to measure. Ultimately, male moth traps, which are the most economical survey device, could be deployed systematically to assess both population levels and trends over broad areas.

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